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MANAGEMENT OF CLOVERS ON CALIFORNIA ANNUAL GRASSLANDS

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WHY PLANT CLOVER ON ANNUAL GRASSLAND?

The nonirrigated grasslands of California are dominated by annual herbaceous species growing on soils of generally low fertility. These soils are usually deficient in nitrogen and often in phosphorus and sulfur. To increase production on these grasslands, nitrogen must be added either by fertilization or by growing clovers which, together with root-nodule bacteria, have the ability to convert the nitrogen in the soil air into a form that can be used by plants.

This circular discusses the advantages of seeding clovers on grasslands, describes several species, recommends management practices, and suggests suitable mixtures for California's various rainfall and planting zones.

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MANAGEMENT OF CLOVERS ON CALIFORNIA ANNUAL GRASSLANDS

Clovers Increase Feed Production and Quality

California annual grasslands are characterized by extremely low production during the cool winter months, rapid growth during the spring, followed by low-quality forage during the dry summer and fall. Where winter annual legumes, such as subclover, rose clover, or bur clover, are present, they provide an almost ideal solution to the problem of poor winter feed production and low-quality summer feed. The winter forage production of planted clover-grass pasture is greater than that of native pasture. Good clover stands also increase the level of protein throughout the growing season and it usually remains high enough to meet animal protein needs during the summer months. Some seeded subclover pastures in northern California carry two ewes per acre and market two 90- to 100-pound lambs by the middle of June. In contrast, 3 to 4 acres are often required to carry one ewe on an unimproved pasture. Fourfold increases over production on unimproved pastures have been reported on the eastern edge of the Sacramento Valley with the establishment of annual clover and fertilization with single superphosphate.

Establishment of annual clover pasture costs about $23 per acre on foothill or old grainland. This includes disking, seed, inoculant, planting, rolling, and fertilization with 500 pounds of single superphosphate per acre. Such treatment increased carrying capacity on foothill pastures from 0.5 to 3 animal-unit months (AUM) per acre. (An animal-unit month equals one beef animal per month.) The same treatment on nonirrigated grainland gave a carrying capacity of 5.9 AUM. The treatments were paid for in about one year when pastures were rented at $5/AUM, and will last many years if the pastures are properly grazed and 100 pounds single superphosphate per acre are applied every other year.

Low-quality, summer dry forage dominates California annual range. Because protein levels are insufficient to maintain livestock, economic utilization of this "natural" range is limited. Well-managed range clover pastures, when dry, will be at protein levels of about 12 per cent, which is well above the minimum requirement for both cattle and sheep. Thus, total dry-matter production is not only increased, but the quality of the summer forage in the field is also much better. Livestock like dry clover, and readily eat enough to do well on it. This high-quality forage cannot be attained during the summer months through nitrogen fertilization. Nitrogen fertilizer does increase winter and spring production (fig. 1), but it causes the grass to grow faster than the clover, thus reducing the total clover contribution to forage production, as well as the percentage of protein.

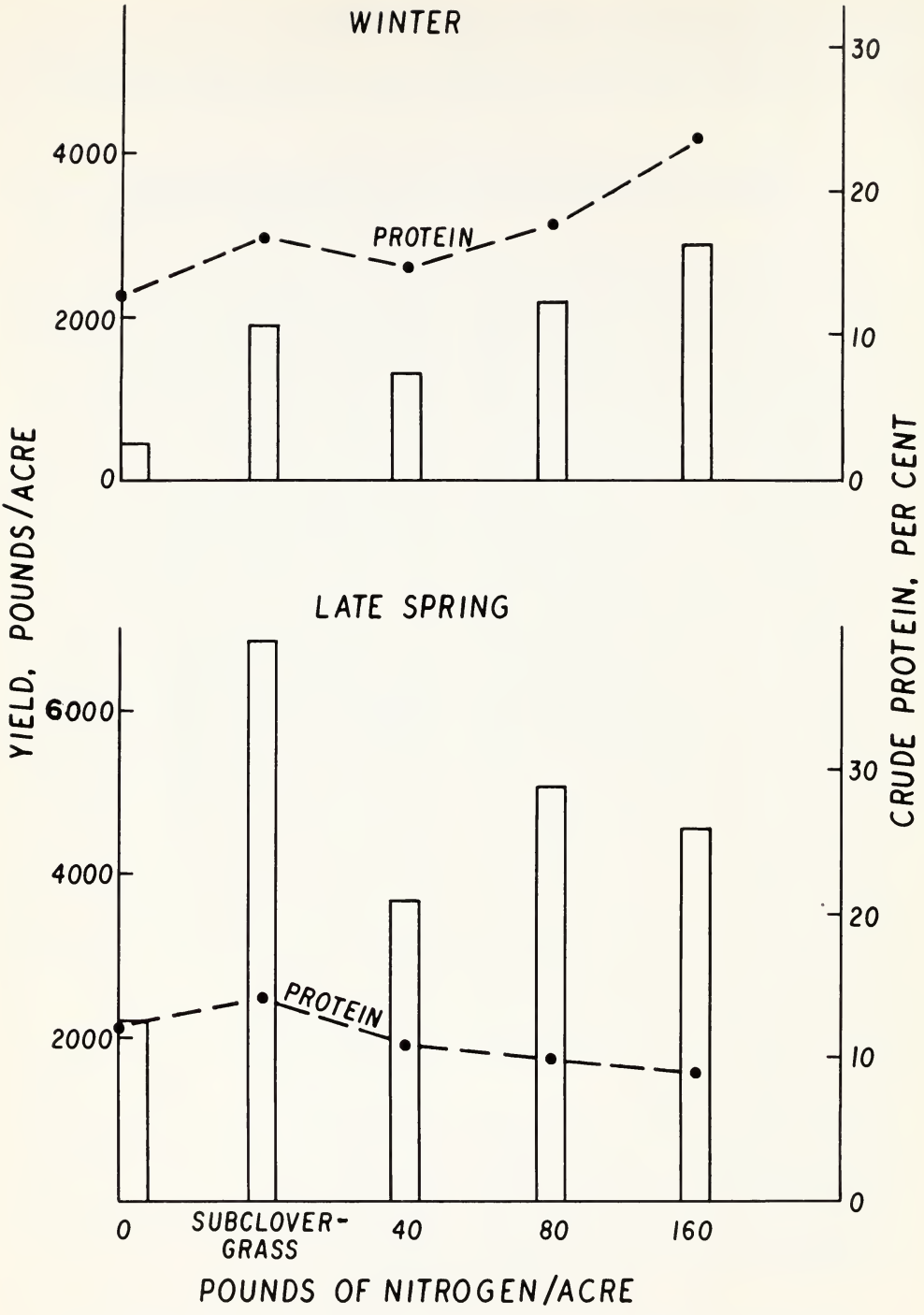


Fig. 1. Influence of nitrogen fertilizer and subclover on forage yield and protein content.

TABLE 1. ROSE AND CRIMSON CLOVERS FACT SHEET

Variety	Weeks to flowering after Olympus	Minimum rainfall (inches)*	No. seeds per pound	Remarks
Rose clover:				
Olympus	February	10	155,000	Prostrate growth
Hykon	1–2	12	135,000	Semi-erect growth
Kondinin	3–4	12	165,000	Upright growth
Wilton	5–6	15	160,000	Common California variety; good seed production under dry conditions
Crimson clover	3–4	15	140,000	Bright flower; easily grazed out with close grazing; good cool-weather growth

* Rainfall distribution is important as well as total rainfall. Minimum rainfall values indicate that the clover should be expected to reseed in an area of the state with the long-term annual rainfall indicated.

Clovers generally available commercially for seeding nonirrigated grasslands include crimson, rose, and subterranean, and several medics. (The medics are so called because they are in the genus *Medicago*.) All of these species are annual plants that germinate from seed each year at the beginning of the rainy season in the fall. Germination usually starts with 1 inch of rain if most of it falls at a time when soil moisture can be maintained.

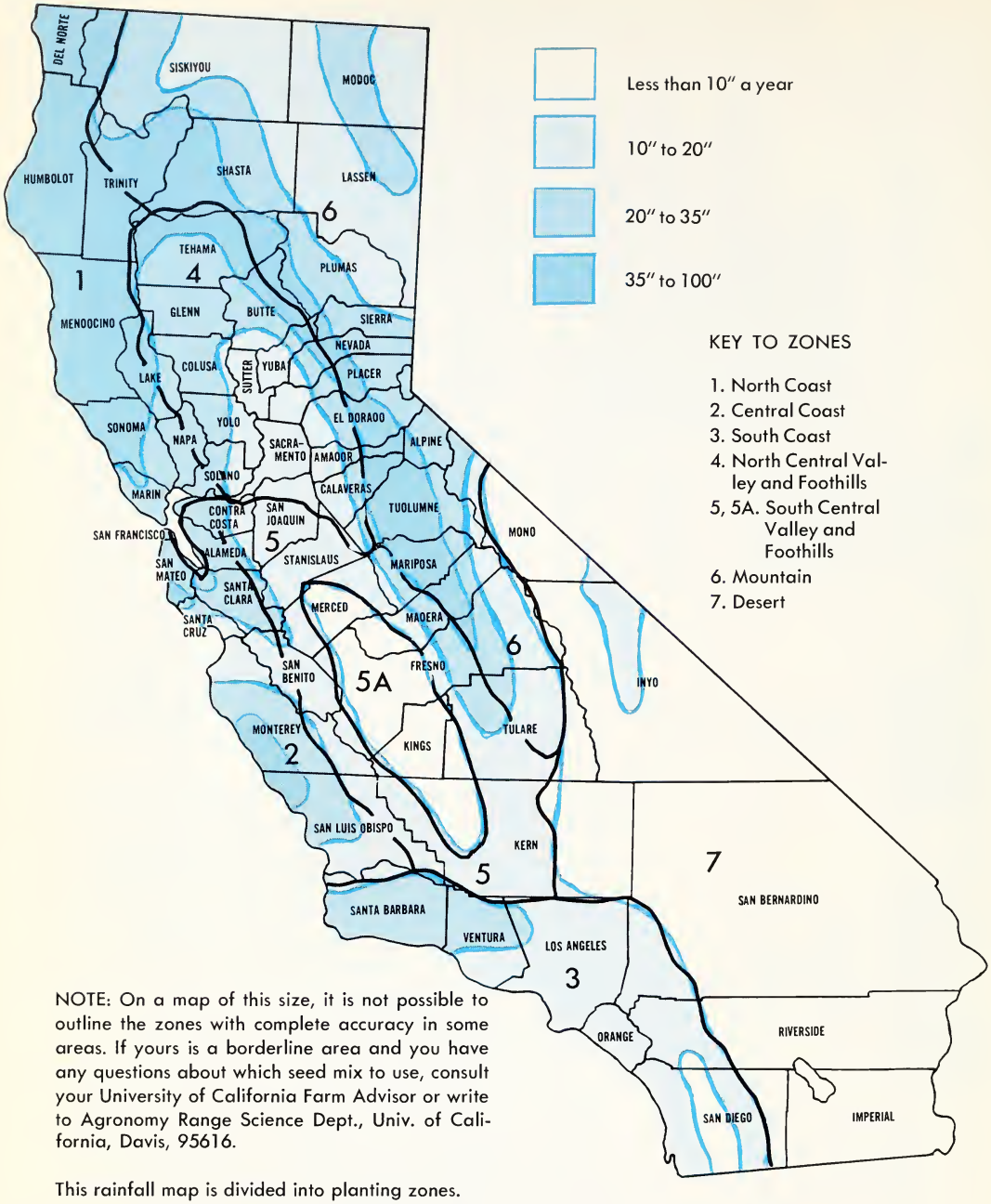
Germinating clover plants appear with two oblong, smooth-edged cotyledons; these are soon followed by a single, clover-shaped leaflet, and then by the typical trifoliate clover leaf, characteristic of many clover plants. From the emergence of the first cotyledons to the appearance of the first trifoliate leaves, the clover plants are quite easily damaged by frost. Thus rapid growth initiated by early fall rains, while temperatures are mild, is an advantage at this early growth stage.

As the cold winter temperatures moderate and daily averages are above 50° F, plant growth quickens and leaves appear rapidly. Flowers appear from January to May, depending on variety, followed shortly by seed production. At maturity the leaves and seed pods dry, and seeds harden.

Rose Clover (*Trifolium hirtum*)

Rose clover (fig. 2; table 1) is able to survive harsh conditions of poor, rocky soil and low rainfall (to 10 inches annually), and usually is a good forerunner to other clovers on low-fertility soils. It produces well under better soil and rainfall conditions, especially on well-drained soils.

This upright, branching clover has light-green leaves covered with dense, short hairs, and a "watermark" of white or reddish-brown, either a spot or a cres-



NOTE: On a map of this size, it is not possible to outline the zones with complete accuracy in some areas. If yours is a borderline area and you have any questions about which seed mix to use, consult your University of California Farm Advisor or write to Agronomy Range Science Dept., Univ. of California, Davis, 95616.

This rainfall map is divided into planting zones.

RECOMMENDED MIXTURES OF ANNUAL LEGUMES ADAPTED TO CALIFORNIA

The recommendations, in pounds per acre, are typical for each area. If you wish more specific information, consult the University of California Farm Advisor for your county. See the map for location of zones.

ZONE 1: North Coast (rainfall 35" or more)

- 2—Geraldton and/or Daliak subclover
- 2—Woogenellup and/or Howard subclover
- 3—Mt. Barker subclover
- 2—Tallarook subclover

ZONES 1and 2: North and Central Coast; coastal valleys (rainfall 20–35")

- 2—Geraldton and/or Daliak subclover
- 2—Woogenellup and/or Howard subclover
- 2—Dinninup and/or Seaton Park subclover
- 2—Mt. Barker subclover
- 1—Wilton rose clover

ZONES 2, 4, and 5: Central Coast and higher foothills (rainfall 15–35")

- 2—Geraldton and/or Daliak subclover
- 2—Woogenellup and/or Howard subclover
- 1—Dinninup and/or Seaton Park subclover
- 1—Mt. Barker subclover
- 2—Jemalong and/or Harbinger barrel medic
- 1—Hykon and/or Kondinin rose clover
- 1—Wilton rose clover

ZONE 3: South Coast (rainfall 10–20")

- 2—Geraldton and/or Daliak subclover
- 2—Hykon and/or Olympus rose clover
- 2—Jemalong and/or Harbinger barrel medic

ZONES 4, 5, and 5A: Central Valleys (rainfall 10–20")

- 2—Wilton rose clover
- 2—Hykon and/or Kondinin rose clover
- 2—Dinninup and/or Seaton Park subclover
- 2—Geraldton and/or Daliak subclover
- 2—Woogenellup and/or Howard subclover

CLOVER FOR SPECIAL USES

1. Clare subclover—Replace part of other midseason varieties (Woogenellup, Howard, Seaton Park, or Dinninup) on heavy soils with pH of 7.5–9.
2. Yarloop subclover—Replace midseason varieties on waterlogged soils.
3. Crimson clover—Replace part of rose clover; good for grainland rotation.

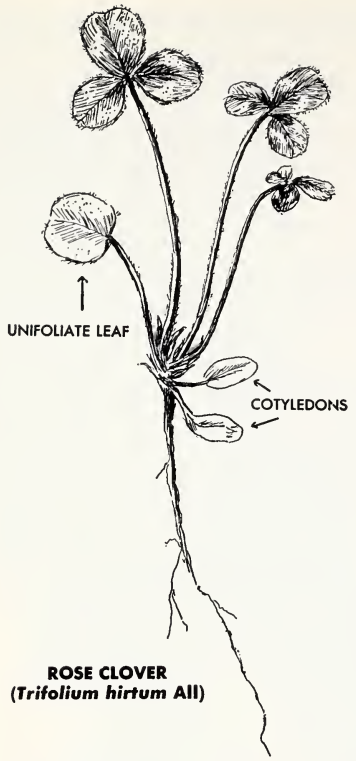


Fig. 2. Young plant of rose clover, with identifying features.

cent. Flowers are rose-colored, globular, with abundant, soft hairs. The light yellow seed will develop under adverse situations of moisture and soil fertility. Like many legumes, it produces a percentage of "hard seed"—that is, seed with a coat that prevents intake of water, thus delaying germination from one to several years, and insuring a continuing seed supply. Both green and dry, the foliage is good feed for livestock and wildlife. The seed is a valuable fall and winter feed for quail and other upland game.

Before 1960, only one commercial strain of rose clover was available, but other specific strains have since been developed that are more flexible for varied climatic conditions. Rose clover is a native of the Mediterranean area, and was first planted in California in 1944 near Wilton, in Sacramento County. The progeny of this first introduction became a certified variety in 1949, known as Wilton rose clover. Subsequent research in Australia has led to the development of other varieties now used in California—Olympus, Hykon, and Kondinin (table 1).

Subterranean clover (Trifolium subterraneum)

Subclover (fig. 3; table 2), a native of the Mediterranean region, came to California via Australia in about 1933. Most of the seed for commercial sale is produced in Australia.

Subclover selection and breeding programs in Australia have resulted in the availability of a wide selection of strains. One of the major differences among the strains is the length of time required for the plant to produce seed, which may be as much as 60 days between earliest and latest strains. This makes it possible to find strains adapted over a wide range of rainfall zones and soils.

Subclover is characterized by its habit of burying some of its seed-producing burs below the ground surface; the seed is thus protected even with close grazing. The hairy foliage is produced on numerous recumbent runners, in a dense, matted ground canopy. Flowers are small, inconspicuous, mostly white blossoms which at maturity usually produce four seeds in a fibrous bur. The naked seed is round and usually black; a few white-seeded varieties are the exceptions. The seed often supplies a good source of feed during the summer, keeping sheep in good condition even when the ground appears bare.

For satisfactory growth, subclover requires more than 10 inches annual rainfall, elevations below 4,000 feet, and neutral to moderately acid soils.

The strains of subclover may be grouped, according to the length of time required to reach maturity or seed set, as early, early mid-season, mid-season, and late-season strains. A short growing

Fig. 3. Subterranean clover (Trifolium subterraneum L.). A. Growth habit; B. stages of flower development; C. leaf; D. leaflet; E. flower; F. and G. seed heads; H. seed. (Illustration from Bul. 2424 of the Department of Agriculture of Western Australia, by permission.)

season, which can result from low rainfall, high evaporation, shallow soils with southern exposure, or high elevations, would suggest the early strains, such as Geraldton, Dwalganup, or Daliak. Where more favorable conditions exist, with an increased growing period, the mid-season strains, such as Dinninup, Woogenellup, or Mt. Barker, would be suitable. In contrast, the late strain, Tallarook, requires at least a five-month growing season (table 2).

Several strains fit into special situations. Yarloop, for example, will tolerate

TABLE 2. SUBCLOVER FACT SHEET

Variety and start of flowering	Minimum rainfall (inches)*	Estrogen level	No. seeds per pound	Remarks
Early-season (late Jan.–early Feb.):				
Geraldton	10	High	85,000	Leaves sparse; long runners; abundant seed producer; winter producer
Dwalganup	12	High	85,000	Will continue growth with late rains; seed limited
Daliak	12	Low	80,000	Good winter growth; high level of hard seed
Early-midseason (mid-Feb.–March):				
Seaton Park	18	Low	65,000	Fair winter growth; stands erratic
Yarloop	18	High	60,000	Tolerant of waterlogged soils; white seed, used in special situations; subject to frost injury; stands erratic
Dinninup	18	High	85,000	Good producer
Midseason (March and April):				
Woogenellup	20	Low	60,000	Vigorous seedlings; good winter and spring growth
Howard	20	High	80,000	Resistant to clover stunt virus; good winter growth
Clare	20	Low	70,000	Will tolerate higher pH soils; large seeds

Bacchus Marsh	25	Low	75,000	Most burs are produced above-ground; minimum use recommended; good winter growth
Mt. Barker	25	Low	70,000	Most widely used before 1960; good spring growth
Nangella	25	Low	—	Major use in western Oregon; seed supply limited
Late-season (late April and May):				
Tallarook	35	High	60,000	Needs late spring rains; high total production

* Rainfall distribution is important as well as total rainfall. Minimum rainfall values indicate that the clover should be expected to reseed in an area of the state with the long-term annual rainfall indicated.

high soil-water levels, whereas Clare is suitable where lime content of soil is high.

A mixture of several varieties has usually been more productive than any single variety used alone. Because environmental conditions, such as soils, exposure, and moisture, are quite variable even within one small field on California's annual grassland, a mixture of varieties is desirable to provide the genetic variability required under such conditions. The mixture recommended depends on local conditions and the availability of seed (see Seed Mixtures, p. 7).

Crimson Clover (Trifolium incarnatum)

The showy crimson flower makes this plant the most readily recognized annual clover (fig. 4; table 1). The light-green foliage is covered with soft hairs; the leaves are usually unmarked, but sometimes have a few dark-red spots; the plant branches less than does rose clover, and can grow to 1½ feet in height. Crimson clover grows in either clay or sandy soils, and to set seed and reproduce well it requires moisture at least through April. This clover is often used as a hay crop or for roadside plantings as well as for range seeding.

Crimson clover is not adapted over so wide a range of conditions as is rose clover. The seedheads are easily accessible for use by grazing animals, and removal of all seed-producing heads must be prevented if reseeding is to be assured. Crimson is best suited for short-rotation planting, for use in a mixture with grains, as a rotation crop with grains, and is sometimes cut for hay.

Bur Clover (Medicago hispida)

The best known plant among the medics (fig. 5; table 3) is bur clover. Since it has been established in California for about two centuries, most people regard it as a native. However, none of the med-

Fig. 4. Crimson clover (Trifolium incarnatum L.). A. Growth habit; B. leaf; C. flower; D. calyx; E. seeds. (Illustration from Bul. 2424 of the Department of Agriculture of Western Australia, by permission.)

ics is native to California. Bur clover's growth habit of numerous prostrate stems (in a thick stand they may become erect), prolific seed production, rapid growth following fall rains, and ability to fix nitrogen make it closely resemble a true clover, which it is not. Bur clover is normally less tolerant of acid soil than is subclover, generally prefers valleys and low foothills, and will produce plants in low-rainfall years if winter temperatures are not too cold (table 3). It is not usu-

TABLE 3. MEDICS FACT SHEET

Variety	Weeks to flowering after Cyprus Barrel	Optimum rainfall (inches)	Soil type	Soil pH	Character of spines	No. seeds per pound
Cyprus Barrel	January	10–16	Heavy	7–9	Short, straight	125,000
Bur	4–5	10–25	Heavy	4.7–8	Hooked	145,000
Harbinger	1–2	10–24	Sandy	6–8.5	Short, straight	190,000
Hannaford	3–4	10–20	Medium to light, alkaline	7–9	Short, straight; unhooked	110,000
Jemalong	3–4	10–17	Calcareous, sandy	7–9	Short, straight; unhooked	110,000

Fig. 5 Young plant of bur clover, with identifying features.

ally seeded on range because in most parts of California where it is adapted, the seed is present and can be encouraged with cultivation, fertilization, and proper grazing. Plants, both green and dry, and burs provide good feed.

Seed is produced in rounded, coiled burs surrounded by short, hooked spines which adhere to animal coats and thus aid seed distribution. However, burs clinging to sheep fleece reduce its value. A high percentage of the seed is hard, thus assuring a supply on the range from year to year. Commercial supplies of seed are sometimes limited.

Several other medics available commercially can be used where conditions favor bur clover. Developed in Australia, they include Jemalong, Cyprus Barrel, Hannaford (*Medicago truncatula*) and Harbinger (*M. littoralis*). These medics are considered best for planting where rainfall is low (below 15 inches annually) and the growing season short, because most of the other clover types will not survive such conditions. The medics will also persist under a wide range of rainfall and soil conditions.

Arrowleaf, Lupines, and Vetch

Arrowleaf clover (*Trifolium vesiculosum*) has been tried experimentally in numerous California tests and has survived for several years. This plant has showy, white to pink-purple flowers and a rather broad, arrow-shaped leaf with a large white V on the upper surface. Arrowleaf, a late spring grower, matures later than does crimson clover, and thus probably will only survive where late spring moisture is assured.

Lupines are used for seeding in some areas of Australia. They have been tried in California, but they apparently do not fix as much nitrogen as do either clovers or medics. Because some species cause an alkaloid poisoning in sheep, only those with low alkaloid content, such as New Zealand Blue or Uniwhite (*Lupinus angustifolius*) varieties should be considered as feed. Lupines produce considerable amounts of hard seed, but when dry, the seed is readily eaten by animals, as are the stalks. These plants do best where annual rainfall is at least 20 inches and soils are well drained.

Vetches are useful as a source of spring feed, but their best use is for summer dry forage, or where a seed supply is needed for upland game birds. Both common vetch (*Vicia sativa*) and purple vetch (*V. benghalensis*) are the most usual species found as wild escapes in fields and pastures. For range seeding purposes, Lana woolypod (*V. dasycarpa*) is the preferred variety. It offers the best nutritive quality and ability to persist from year to year. Although it may be seeded broadcast, superior results are obtained by drilling in a prepared seedbed. Best growth is obtained by inoculating the seed, fertilizing with adequate amounts of phosphorus and sulfur, and seeding on moderately acid to moderately alkali soils where rainfall is 16 inches or more. To insure high-protein feed in summer and early fall, grazing should be deferred during the growing season.

Fig. 6. Left: Clover seeded with drill-seeding equipment shows better germination and vigorous plants. Below, left: Rangeland drill for seeding clover on cultivated or noncultivated range. Ringroller behind drill aids seed coverage. Below, right: clover seeded with rangeland drill and fertilized with phosphorus showed vigorous growth in first season.

Successful establishment of clover requires proper seeding time, the right kind of seedbed preparation, seed inoculation, correct planting depth, fertilization, well-managed grazing, and a minimum of competition from other plants.

Inoculation

Many soils either lack root-nodule bacteria or contain ones that do not fix nitrogen. Efficient nitrogen-fixing bacteria of the proper strains must be introduced by planting inoculated seed. Establishment of high-producing clover stands depends on use of inoculum especially prepared for the rose and subclovers and the medics. The native bacteria in the soil are highly competitive with the introduced bacteria on inoculated seed, and the latter must be protected until the seed germinates. Pellet inoculation is an improved technique that concentrates high numbers of live bacteria on the seed and helps protect them until germination.

Each seed pellet contains a clover seed, the inoculant, and an adhesive and a coating material that influence the survival of the bacteria. The grower may prepare the pellets in a cement mixer or on a concrete floor, or he may order inoculated seed from a dealer. (Details of pellet inoculation are given in University of California Agricultural Experiment Station Bulletin 842, "Range Legume Inoculation and Nitrogen Fixation by Root-Nodule Bacteria," and Agricultural Extension Service Publication AXT 280, "Pellet Inoculation of Legume Seed.")

Seedbed Preparation and Sowing

Seeds that are not covered may be taken by birds and rodents as food; this loss is substantially reduced when seed is covered by soil. In natural stands, seed is produced in great abundance, which compensates for some losses; however, the rancher cannot afford this high rate of seed sowing. Covered seed absorbs moisture better than does seed exposed to sunlight and air, thus the seedlings usually germinate and emerge sooner. The inoculation materials also have a better chance for survival when they are not damaged by exposure to heat and sunlight.

Planting should not be too deep, however, because that can be more harmful than no covering at all. Do not plant seed over ½ inch deep. Clover seeds are small, and if they are buried too deep, the germinating plants will be unable to reach the soil surface for development. Planting depth can be controlled if soil is smooth, with a minimum of large clods, and has been rolled for firmness before seeding.

Where ground can be cultivated, it is beneficial to plant a crop of sudangrass in the preceding summer or a crop of grain in the previous year. This practice results in lowered competition from weedy annual plants and provides a firm seedbed. Seed is sown directly into the stubble, with no further seedbed preparation, and covered by using a ring-roller. In some cases clovers are planted with grains, but this practice requires careful management to prevent crowding out of the clover. If this type preparation is not feasible, the ground may be lightly disked to provide some loose soil for seed coverage, and then planted before the fall rains. If the seed is not drilled, a roller or some type of drag should be used to cover the seed with soil.

The white ash of a brush burn in wildland areas is a better medium for seeding than is the darker ash. The seed is usually sown broadcast, often by aircraft, and sinks into the soft ash unless moisture has caused the ash to form a crust. The ash of a grass burn is generally not a satisfactory seedbed for broadcast seeding. Plac-

ing seed in the ground, by means of planting equipment, is better than applying it broadcast. A better stand usually results when seed is planted before the first rain, rather than after.

On areas not suitable for cultivation, a rangeland drill or similar seeding equipment that will cover the seed with some soil will improve results (fig. 6).

Seeding by early October, even in dry soil, provides better opportunity for plant development than does seeding in mid- to late November. Cold temperatures slow plant growth, and frosts can cause soil to heave and push small clover plants out of the ground. A larger clover plant is better established to survive low temperatures than is one that has just germinated. If the clover can start growing about the same time as the other resident annual plants it will have a better chance of competing for space and light as the season progresses.

In a new seeding, the critical stage of clover development is the first growing year. A primary objective in the first season is to produce an abundance of clover seed to provide a productive stand for the following years. If the clover planting has to compete with an abundance of grass and weeds, the clovers will be stunted and seed set decreased. Good seedbed preparation helps prevent such competition.

Fertilizing and Grazing New Clover Stands

The amount of fertilizer to be applied at time of seeding will depend on the previous history of the field and the available soil phosphorus. The latter can be determined in a commercial soil-testing laboratory by the sodium bicarbonate-extraction soil test. If the field to be planted has not been previously fertilized or the phosphorus is less than 5 parts per million (ppm), apply about 500 pounds single superphosphate per acre, to supply both phosphorus and readily available sulfur. Where soil tests show more than 5 ppm phosphorus, less fertilizer may be used (see Fertilizing and Grazing Established Stands).

Do not apply nitrogen to new seedings of annual clovers since this merely increases competition from grass species in the pasture and reduces nitrogen fixation by the bacteria in conjunction with the clovers.

Weed competition can be reduced by grazing, which keeps the faster growing weeds and grasses from overtopping the clover. As a rule, if the soil is not too soft and muddy, a new field should be kept grazed to about 3 inches in height until seed heads appear on the annual grasses. At that time, livestock start to eat the clovers selectively, and should then be grazed in other fields until the clover seeds are ripe and dry.

Fig. 7. Bur clover shows excellent response where sulfur is added to correct the deficiency.

For best results from clover pastures, adequate levels of mineral nutrients must be maintained in the soil.

Phosphorus deficiencies on grasslands are widespread. Clover plants growing without sufficient phosphorus are small, with small, dark-green leaves. Soil phosphorus levels are rated as very low (5 ppm); low (5 to 10 ppm); intermediate (10 to 20 ppm); and high (over 20 ppm). Based on those ratings, fertilizer should be applied as follows:

Available Soil Phosphorus (ppm)	Amt. Single Superphosphate or Equivalent (lb/A)
Less than 5	500 every third year
5–10	250 every third year
10 or over	100 every second year

After two or three heavy applications on low-phosphorus soils the soil levels should be increased to the point where only maintenance amounts are required. Even where soil phosphorus is high, light applications every second year increase clover production by replacing phosphorus and sulfur (figs. 7 and 8) removed by grazing.

Single superphosphate also supplies sufficient sulfur (about 12 per cent) except where rainfall is greater than 30 inches. In the wetter areas of the state, apply about 50 pounds per acre of soil sulfur or its equivalent every other year. If a high percentage of the sulfur will not pass through a 50-mesh screen, use from 100 to 200 pounds per acre. The larger particles will last longer.

On stands older than one year, the clover can be more heavily grazed if the soil phosphorus and sulfur supplies are adequate. As a general principle, clovers do better in short pasture (3 to 6 inches), whereas grasses do better if the forage is at 6 to 12 inches. If clover is permitted to grow dense and rank, especially subclover, the shaded, lower leaves die and rot before they are eaten. Flowering and seed production may also be reduced by rank growth. Grazing on rose and crimson clover, which produce flowers at the ends of stems, must be regulated to keep animals from removing all the flowers. Once established, most clover plantings thrive best with fairly close, continual grazing to keep down rank growth.

Fig. 8. Clover in this field (Sonoma County) will grow only if sulfur is added, as shown by untreated area, left, and treated area, right.

Stands of adapted clovers should last indefinitely with proper grazing and fertilization. As clover-produced nitrogen accumulates in a pasture soil, foxtail grasses and other objectionable plants tend to increase, but close grazing helps to maintain the clover stand. On more easily farmed fields, after a number of years of clover pasture, it is not uncommon to rotate into one or two successive crops of cereal grain or hay and then reseed to clovers. A mixture of clovers

and grasses can also produce excellent quality hay if a good balance of the two plants is maintained. Hay production has a tendency to favor grass; thus it may not be suitable to use the same field every year for hay if the clover is to be sustained.

Forage-related Problems

Many feeds are toxic in a specific way. For example, bur clover can cause bloat, which seldom occurs with rose and subclovers. Subclovers contain varying amounts of pigments that can have estrogenic effects on animals. In Australia, estrogen levels of some subclover varieties, in nearly pure stands, have become a critical factor in reducing lambing percentages. This has not been a problem in California because (1) subclover usually is not over 50 or 60 per cent of the stand even in the best pastures; and (2) subclover varieties high in estrogen (Yarloop, Dinninup, Tallarook) have not been widely used, and when they have been planted, they have usually been mixed with low-estrogen varieties.

Watch for Disease and Pests

Cold, foggy midwinter is a poor growing season for clovers, and they often appear unthrifty at that time. Low temperature and dim light are the main reasons for poor growth, but a number of pathogens might also be involved. Treatment is, however, too costly to be practical. Some of the more common maladies of clover and medics are listed for diagnostic purposes. None of these diseases is known to be toxic to livestock.

Damping-off disease usually attacks young plants and is often caused by fungus of the genus *Pythium*. Infection usually occurs just below the soil line, invades plant cells and kills the seedling rapidly. *Pythium* is a natural inhabitant of soil in most locations. Seed treatment offers protection in some crops, but is not very effective with small-seeded legumes. Some species and varieties seem more susceptible than others. This may be a reason for relatively poor performance of rose clover in damp north-coastal areas.

Sclerotinia is a fungal disease, sometimes called water mold, that is present in the soil. It appears in legumes in late February through early April, as dead, watery vegetation in scattered spots about 6 inches in diameter. It is usually most damaging in dense, ungrazed clover that is 4 or more inches tall. The spots rapidly increase in size to several feet in diameter. A dense white mycelial web covers the dying clover. Within 10 days little hard, black sclerotia (lumps of mycelium) should be evident on the soil surface. They look like large, irregularly shaped subclover seeds, but are soft enough to cut open with a thumbnail, and are white inside. With drying weather the disease disappears as rapidly as it arrived. A wide range of legumes is affected. Treatment is impractical. Rank, ungrazed fields are most severely affected.

Pepper spot ***(Pseudoplea trifolii)*** is a fungus common on clovers in February and March. As the name implies, little black spots appear on leaflets and petioles. Severe infection causes the leaf to turn yellow, then brown, and the dead tissue is dotted with tiny black fruiting bodies of the fungus.

Powdery mildew ***(Erysiphe polyoni)*** is quite common as a very thin, white, powdery growth on leaves of subclover in coastal areas in late spring.

Other fungal diseases causing warts, galls, leaf blotches, and abnormal growths on legumes have been recorded in California. They are not common, and are of little economic importance.

Nematodes have been found on subclover roots in California and Australia, but their economic significance is unknown.

Insects can be quite damaging locally and periodically. For the most part they do not eliminate the legume attacked, and chemical control is usually impractical. In spring, a number of named and unnamed *mites* (tiny spiders) can cause severe leaf damage locally. In several locations along the Sierra foothills, infestations of a small *leaf tier* caterpillar have occurred. This insect ties the folded legume leaf together with a web, and lives inside, feeding on the leaf. The *alfalfa weevil* and *clover leaf weevil*, both legless green larvae about ½ inch long, can be very damaging in late spring, when they feed on the growing tips and young leaves. Alfalfa weevil damage on bur clover can be so widespread that most plants are almost completely skeletonized.

Rodents and Birds

Field mice, kangaroo rats, and birds sometimes take such large quantities of seed that maintaining a stand becomes difficult. The loss is high where seed is broadcast without cover. Gophers and ground squirrels, in addition to using seed, also cause considerable damage by destroying growing plants. Rodents can threaten a planting if controls are not initiated. Under some situations, trapping and baiting can provide economical control of rodents, but such control of birds and insects is generally not possible.

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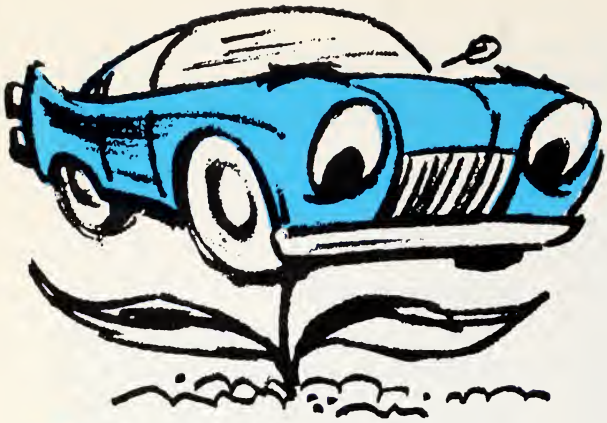

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. . . . . 900,000 bushels of corn
736,000 bushels of flaxseed
74,000 bales of cotton

or, *in terms of approximate acreage:*

. . . . . 15,000 acres of corn
80,000 acres of flax
78,000 acres of cotton

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